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VERIFICATION OF TRANSLATION

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that to the best of my knowledge and belief the following is a true and correct
translation of Japanese Patent Application No.H10-303750.

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[Title of the Invention] An Image Pick-up Device

[What is claimed is:]

1. An image pick up device comprising:
 - a pick-up unit for picking up an image condensed on a liner sensor through a lens;
 - 5 a chromatic aberration correction board with a predetermined pattern in accordance with a pick-up resolution;
 - an interpolation factor calculation unit for calculating chromatic aberration interpolation factors to be used for a chromatic aberration correction by using digital image data on the chromatic aberration correction board picked up by the pick-up unit;
 - 10 a line memory for storing the chromatic aberration interpolation factors calculated by the interpolation factor calculation unit; and
 - a chromatic aberration unit for correcting the image data picked up from an original image by using the chromatic aberration interpolation factors outputted from the line memory.
- 15 2. An image pick-up device comprising:
 - a pick-up unit for picking up an image condensed on a liner sensor through a lens;
 - a chromatic aberration correction board with a predetermined pattern in accordance with a pick-up resolution;
 - a character amount extraction unit for finding a character amount of the image by
 - 20 using digital image data on the chromatic aberration correction board picked up by the pick-up unit;
 - an interpolation factor setting unit for setting chromatic aberration interpolation factors to be used for a chromatic aberration correction in accordance with the character amount extracted by the character amount extraction unit; and
 - 25 a chromatic aberration correction unit for correcting the image data picked up from an original image by using the chromatic aberration interpolation factors set by the interpolation factor setting unit;
3. The image pick-up device according to Claim 2 characterized by said interpolation factor setting unit having a line memory for storing a character amount.

4. The image pick-up device according to Claim 2 characterized by said interpolation factor setting unit for setting chromatic aberration interpolation factors at a changing point where a character amount changes.

[Detailed Description of the Invention]

5 [Technical field to which the invention pertains]

The present invention relates to an image pick-up device for picking up a manuscript image.

[Description of the related arts]

When an image of a color manuscript is picked up, the reflection light from the manuscript is focused on a CCD sensor through a lens to be converted into an electric signal. This electric signal is further converted into digital image data to be outputted from a printer or the like. As shown in Fig. 1, when a white light goes through a lens, depending on the difference of the wave length of the light components, the longer the wave length of the light is, the more inside it condenses, while the shorter the wave length of the light is, the more outside it condenses, which is more so at the edge of the lens compared to at the central part of it. Therefore, when an image like a vertical line is condensed on the CCD sensor, the phases of R(red), G(green) and B(blue) are shifted from each other. In this manner, the light is influenced by the chromatic aberration of the lens to cause a color shift at the edge of the CCD sensor in the main scanning direction.

A chromatic aberration is not a problem with an image of a comparatively smooth density profile such as that of color patches. It causes, however, a color shift at the edge of a letter or the like. Especially, at the edge of a black letter, a mistaken determination causes a color bleeding or a separation of the letter around the periphery of the letter. Therefore, high quality lenses are required for a copier using a color CCD sensor. However, even if the lens function was improved, the lens system would be larger, which ends up with a larger image pick-up device including the optical system. And the lack of uniformity among the lens part products can't also be ignored. Therefore, it is necessary to correct this chromatic aberration in the image processing system.

[Problem to be solved by the invention]

In picking up an image, the main method for a chromatic aberration correction is to mix adjoining image data by using chromatic aberration interpolation factors. As the chromatic aberration correction circuit shows in Fig. 2, for example, with respect to R and B data picked up through each scanning of a manuscript, a plurality of phase correction circuits
 5 perform a chromatic aberration operation for adjoining three pixels by using plural combinations of phase interpolation factors calculated when the lens(es) are(is) designed, and calculate color saturation data (the maximum value-the minimum value of R, G and B) for each combination of respective colors to select R, G and B data that minimize this value of color saturation. In this way, chromatic aberration is corrected through calculation.
 10 Accordingly, whatever the image data are, the ones with the minimum color saturation are selected. The effect of a chromatic aberration stands out at the edge of black letters but not in other places, therefore, this correction used to be believed enough in practical use.

This color correction operation, however, doesn't have a good correction precision because interpolation factors are fixed. The interpolation factors can only be selected within
 15 limits and moreover, for some image data, different data from the actual chromatic aberration could possibly be selected. And because the interpolation factors depend on the pick-up resolution or the lens system, in case the pick-up resolution or the lens system are changed, it would be necessary to change the whole design accordingly, which means it lacks of the flexibility for general purposes. For general purposes, the interpolation factors should be
 20 variable depending on the resolution or the like.

A purpose of the present invention is to provide an image pick-up device which can output color image information signals that are so stable as not to be influenced by a chromatic aberration.

[Means to resolve the problem]

25 The image reading apparatus pertaining to a first aspect of the present invention includes a reading unit that reads an image by condensing light onto a linear sensor via a lens, a chromatic aberration correction plate having a specific pattern suited to the reading resolution, an interpolation calculation unit that calculates chromatic aberration interpolation factors to be used for color aberration correction using the digital image data regarding the
 30 chromatic aberration correction plate read by the reading unit, a line memory in which are

stored the chromatic aberration interpolation factors calculated by the interpolation calculation unit, and a chromatic aberration correction unit that corrects the image data obtained by reading the original image using the chromatic aberration interpolation factors output from the line memory.

5 In order to detect the condition of chromatic aberration, the data obtained by reading the chromatic aberration correction plate is stored in the line memory, and based on this data, the chromatic aberration interpolation factors to be used in the phase correction calculation for the chromatic aberration are freely set on a real-time basis using the chromatic aberration correction plate. In chromatic aberration correction, for example, the amount of difference
10 between the center of gravity position of R (red) or B (blue) and that of G (green) (the standard) of data for adjoining multiple pixels is sought, and the phase differences are corrected. Because interpolation calculation is carried out based on data obtained by reading the chromatic aberration correction plate, chromatic aberration correction can be freely performed with good precision, and is not affected by the resolution or the lens system. The
15 chromatic aberration interpolation factors, for example, can be set during pre-scanning, or when power is turned ON, via a single factor calculation operation.

 The image reading apparatus pertaining to a second aspect of the present invention includes a reading unit that reads an image by condensing light onto a linear sensor via a lens, a chromatic aberration correction plate that has a specific pattern suited to the reading
20 resolution, a characteristic amount extraction unit that seeks the characteristic amount of the image using the digital image data regarding the chromatic aberration correction plate obtained by the reading unit, a factor setting unit that sets the chromatic aberration interpolation factors to be used for chromatic aberration correction in accordance with the characteristic amount, and a chromatic aberration correction unit that corrects the image data
25 obtained by reading the original image using the chromatic aberration interpolation factors set by the factor setting unit.

 Through this construction, correction for the lens system chromatic aberration that occurs when a color image is read is optimally performed based on the characteristic amounts obtained when the chromatic aberration correction plate was read. For example, the
30 interpolation factor setting unit includes a line memory in which characteristic amounts are

stored. The characteristic amounts regarding the specific pattern are stored in the line memory during pre-scanning. During active scanning, chromatic aberration interpolation factors are set using an interpolation factor table based on that data. In addition, the interpolation factor setting unit sets the chromatic aberration interpolation factor based on the point of change at which the characteristic amount changes. The specific pattern is read during pre-scanning, and the points of change in the characteristic amount sought from the characteristic amounts are stored. During active scanning, chromatic aberration interpolation factors are set based on the points of change.

[Detailed Description of the Preferred Embodiments]

The attached drawings are referred to in describing the preferred embodiments of the invention below. In those drawings, the same reference marks indicate the identical or equivalent parts.

A chromatic aberration is corrected by mixing R, G and B data of adjoining three pixels using chromatic aberration interpolation factors $a1(n)$, $a2(n)$ and $a3(n)$ as follows:

$$R(n) = a1(n) * R(n-1) + a2(n) * R(n) + a3(n) * R(n+1)$$

$$G(n) = G(n)$$

$$B(n) = a3(n) * B(n-1) + a2(n) * B(n) + a1(n) * B(n+1)$$

wherein, n denotes position of R, G or B pixels from the main scanning standard position.

In case predetermined values for chromatic aberration interpolation factors are used, they could be different from the actual chromatic aberration conditions due to the lack of uniformity of the lens products. Therefore, it is necessary to determine the interpolation factors $a1(n)$, $a2(n)$ and $a3(n)$ by finding the chromatic aberration conditions for respective devices. In the present invention, therefore, multiplier factors of the phase correction circuits which correct the chromatic aberration conditions (i.e. the chromatic aberration interpolation factors) are set independently in real time so that the performance of the device is not influenced by the resolution or the lens system.

Fig. 3 illustrates an example of a chromatic aberration correction board used for finding chromatic aberration interpolation factors. The chromatic aberration correction board is provided with a ladder pattern of vertical lines of which number corresponds to a ratio of one for every n pixels in accordance with the pick-up resolution; and it has a width of a

plurality of pixels in the auxiliary scanning direction and a length of the entire scanning span in the main scanning direction. Fig. 4 illustrates the relationships between the pattern of the chromatic aberration correction board and the pixel pitch P of the CCD sensor. In the CCD sensor, the vertical line segments have a width of the pixel pitch P, and each one of them is
 5 detected for every n pixels. Note that, when M is the total pixel number of the CCD sensor, $1 \leq n \leq M/2$ should be satisfied for n. The chromatic aberration correction board is installed on the lower surface of the manuscript glass or the like in a similar way to the shading correction board.

The chromatic aberration interpolation factors are calculated as shown in Fig. 5.

10 Within the image data of the chromatic aberration correction board picked up while pre-scanning or the like, phase shifts of R or B against G (standard) for every n pixels (shift amounts of the center positions of balance) are detected. And from the shift amounts, the chromatic aberration interpolation factors a1(n), a2(n) and a3(n) are calculated and are stored.

The shifts of the centers of balance are calculated as follows: First of all, the address
 15 of G indicating the maximum luminance value in the main scanning direction is found and put as n. Then, the central values of balance are found respectively depending on the luminance values of R, G and B. As the line segments have the width of the pixel pitch, R, G and B signals are gained for adjoining two pixels. For example, in case adjoining address positions n-1, n and n+1 in the main scanning direction have the ratios of luminance values of
 20 PG:QG:0 for G and PR:QR:0 for R, the center of balance of G is $PG/(PG+QG)$ while the center of balance of R is $PR/(PR+QR)$. And the shift amount of the center of balance against G (standard), 1/S, is calculated as follows: $1/S = |PG/(PG+QG) - PR/(PR+QR)|$

Then the interpolation factors a1(n), a2(n) and a3(n) will be found as follows:

$$a1(n) = 1/S$$

25 $a2(n) = (S-1)/S$

$$a3(n) = 0$$

As an example, in case the ratios of the luminance values at the positions of addresses n-1, n and n+1 are 1:4:0 for G and 2:3:0 for R, the center of balance of G is 1/5, the center of balance of R is 2/5 and the shift amount of the center of balance (1/S) is 1/5. Accordingly, a1(n)=1/5,
 30 a2(n)=4/5 and a3(n)=0.

Fig. 6 is referred to in describing a chromatic aberration correction. The chromatic aberration conditions are detected by picking up a specific pattern (a chromatic aberration correction board) 12 through a lens (not shown) at a pick-up unit 10 during the pre-scanning or the like. An interpolation factor operation unit 14 stores the gained image data R, G and B of the chromatic aberration correction board in a line memory (not shown), and finds, according to the above mentioned equations, the shift amounts of center positions of balance of R (red) or B (blue) against the standard, G (green), for every n pixels from the data picked up from the chromatic aberration correction board, and then calculates the interpolation factors $a1(n)$, $a2(n)$ and $a3(n)$ from the shift amounts. It is necessary to determine the chromatic aberration interpolation factors before scanning either by calculating during the pre-scanning or by calculating only at the time of shipment from the plant. The gained interpolation factors are stored in an interpolation factor memory unit (a line memory) 16.

While scanning, the pick-up unit 10 picks up the image of a color manuscript. At that time, interpolation factors corresponding to the image data are read out as required from the interpolation factor memory unit 16, and a chromatic aberration correction operation is performed for R and B data based on the above mentioned chromatic aberration correction operational expressions in a phase correction circuit 18, which results in the outputs as Rout and Bout. The G data are outputted as Gout data as they are. As the phase correction circuit 18 sets the color interpolation factors (the multiplier factors) $a1(n)$, $a2(n)$ and $a3(n)$ which correct the chromatic aberration conditions in this way, it is possible to perform an independent and precise chromatic aberration correction.

The interpolation factors for a chromatic aberration correction, for example, are set in the interpolation factor memory unit 16 by scanning the chromatic aberration correction board when the machine is energized (i.e. when the machine is shipped from the plant or at the time likewise). This enables the setting to have a high degree of freedom with only one time of factor calculation when the machine is switched on.

Fig. 7 shows another embodiment of the invention using an interpolation factor table. In case, for example, interpolation factors themselves were stored in the line memory, it would be necessary to store a plurality of combinations of the factors $a1(n)$, $a2(n)$ and $a3(n)$. Accordingly, the memory capacity of the line memory would become larger. In the present

embodiment, by storing a character amount (for example, color saturation) and by using an interpolation factor table corresponding to the character amount for the chromatic aberration correction, the line memory capacity is eliminated.

Fig. 7 is referred to in describing that a pick-up unit 110 picks up a specific pattern (a chromatic aberration correction board) 112 during the pre-scanning or the like to detect the chromatic aberration conditions. A character amount extraction unit 114 extracts a character amount (for example, color saturation) from the gained image data R, G and B of the chromatic aberration correction board, which is then stored in a line memory 116. (An example of a color saturation extraction is shown in Fig. 1.) An interpolation factor table 118 stores the chromatic aberration interpolation factors corresponding to the character amount inputted from the line memory 116.

When the pick-up unit 110 picks up an image of a color manuscript during the scanning, the line memory 116 outputs data of a character amount into the interpolation factor table 116, and the table 116 outputs the interpolation factors $a1(n)$, $a2(n)$ and $a3(n)$ into a phase correction circuit 118. The phase correction circuit 120 performs the above mentioned chromatic aberration correction operation for R and B data using the interpolation factors $a1(n)$, $a2(n)$ and $a3(n)$, and outputs the results as Rout and Bout. The G data are outputted as Gout data as they are.

Fig. 8 shows yet another embodiment of the invention using a changing point detection to further eliminate the line memory capacity. In this embodiment, like the previous one, color interpolation factors are set based on a character amount gained when a specific pattern (a chromatic aberration correction board) picked up when pre-scanning, but the concrete way of setting is different. Considering the fact that forms of chromatic aberration interpolation factors can be expected to a certain degree, memorizing the changing point of the chromatic operation interpolation factors would make it possible to calculate the factors with a smaller memory capacity. When scanning, therefore, the changing point is found in the changing point comparison circuit based on the changing point of a character amount to set chromatic aberration interpolation factors in the interpolation factor table based on the changing point comparison data.

Fig. 8 is referred to in describing that, while pre-scanning or at some other time, the pick-up unit 210 picks up a specific pattern (a color aberration correction board) 212 to detect the chromatic aberration conditions. A character amount extraction unit 214 extracts a character amount (for example, color saturation) from the gained image data R, G and B of the chromatic aberration correction board 212, and a changing point extraction unit 216
 5 extracts the changing point of the character amount to be stored. An interpolation factor table 222 memorizes chromatic aberration interpolation factors corresponding to the changing point.

While scanning, the pick-up unit 210 picks up an image of a color manuscript. At that time, a changing point comparison circuit 218 compares the changing point stored in the
 10 changing point extraction unit 216 with the pixel address from the main scanning counter 220, and based on the result, finds the interpolation factors $a1(n)$, $a2(n)$ and $a3(n)$ in the interpolation factor table 222 to be outputted to a phase correction circuit 224. In the phase correction circuit 224, the above mentioned chromatic aberration correction operation is performed for R and B data to output the results as Rout and Bout. The G data are outputted
 15 as Gout data as they are.

[Effect of the invention]

As the interpolation factors to correct a chromatic aberration is set independently in
 20 real time, the correction precision is high. And the chromatic aberration correction can be performed without being influenced by the lens resolution or the lens systems.

The correction of the chromatic aberration factors can be performed with a high correction precision when pre-scanning.

As the correction of the chromatic aberration factors can be performed when the
 25 power is turned on or at the time of shipment from the plant or at a similar time to these, the degree of freedom for the setting is high with only one time of calculation for the factors.

The memory capacity for interpolation factors could be eliminated.

[Brief description of the drawings]

30 Fig. 1 is a diagram showing the principle of a chromatic aberration of a lens.

Fig. 2 is a diagram of a chromatic aberration correction circuit according to the prior art.

Fig. 3 is a view of a chromatic aberration correction board with a ladder pattern.

Fig. 4 is a view showing the relationships between a pattern of a color aberration correction board and a pixel pitch of a CCD sensor.

Fig. 5 is a diagram illustrating an example of an operation for chromatic aberration interpolation factors.

Fig. 6 is a block diagram of an image processing system according to one embodiment of the invention.

Fig. 7 is a block diagram of an image processing system according to another embodiment of the invention.

Fig. 8 is a block diagram of an image processing system according to yet another embodiment of the invention.

[Description of the codes]

10: a pick-up unit, 12: a chromatic aberration correction board, 16: an interpolation factor memory unit (a line memory), 18: a phase correction circuit, 110: a pick-up unit, 112: a chromatic aberration correction board, 114: a character amount extraction unit, 116: a line memory, 118: an interpolation factor table, 120: a phase correction circuit, 210: a pick-up unit, 212: a chromatic aberration correction board, 214: a character amount extraction unit, 216: a changing point extraction unit, 218: a changing point comparison circuit, 222: an interpolation factor table, 224: a phase correction circuit.